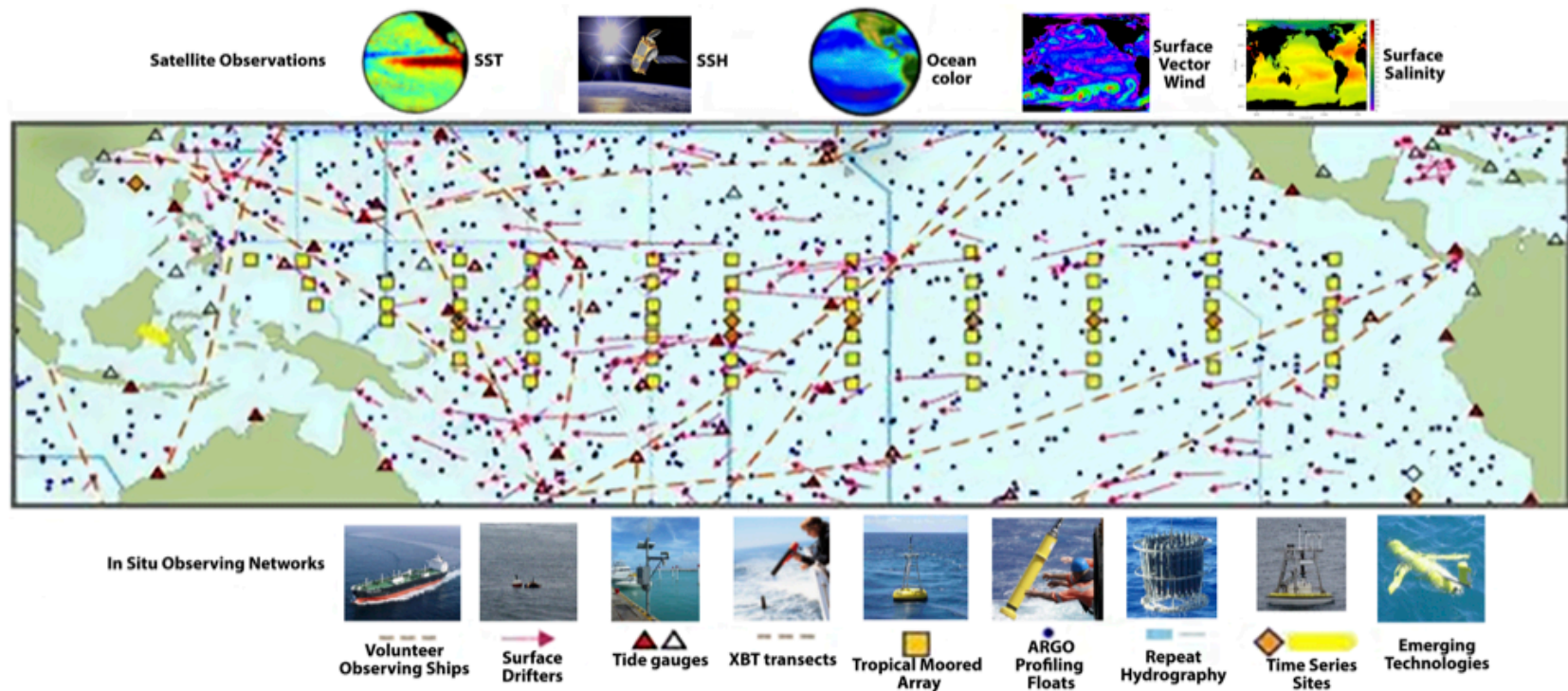


# TPOS 2020 Project

## Review and re-design the Tropical Pacific Observing System

- Rethink in response to new needs, purposes, challenges: Define requirements
- Renew the interagency and intergovernmental cooperation that has been the hallmark of the TPOS since the mid-1980's
- Take advantage of new science and technology



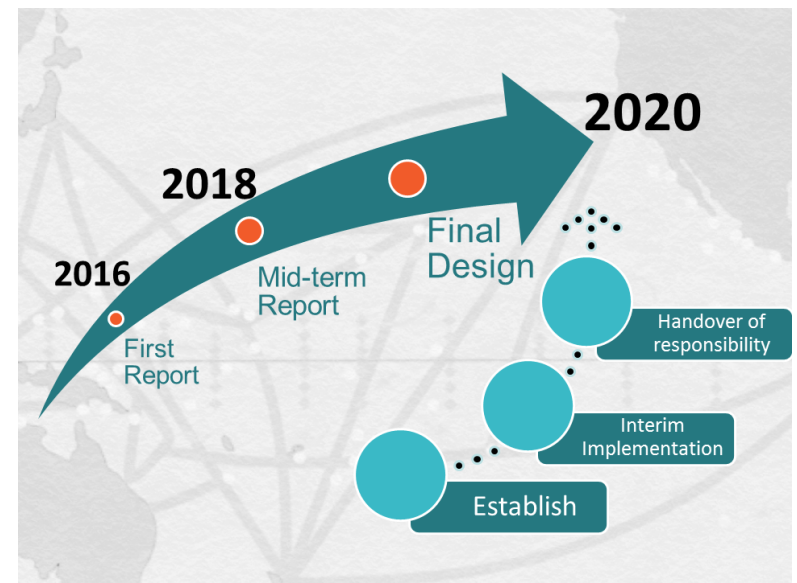
# Why do we care?

- Largest source of intraseasonal to interannual predictability AND prediction
- Largest natural ocean source of CO<sub>2</sub> outgassing
- Sensitivity of the entire climate system to changes in the tropical Pacific



# TPOS 2020 Goals

- To redesign and refine the T.P.O.S. to **observe ENSO** and advance understanding of its causes
- To determine the most efficient and effective observational solutions to **support prediction systems** for ocean, weather and climate services
- To advance understanding of tropical Pacific **physical and biogeochemical** variability and predictability.



# An integrated view

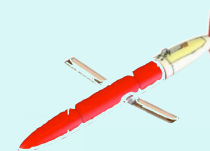
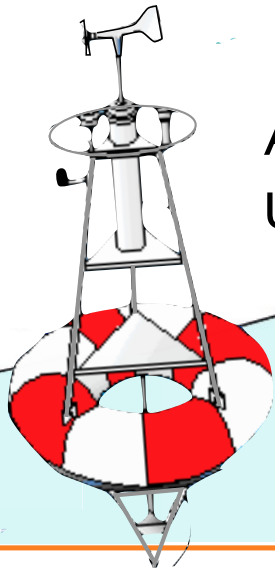
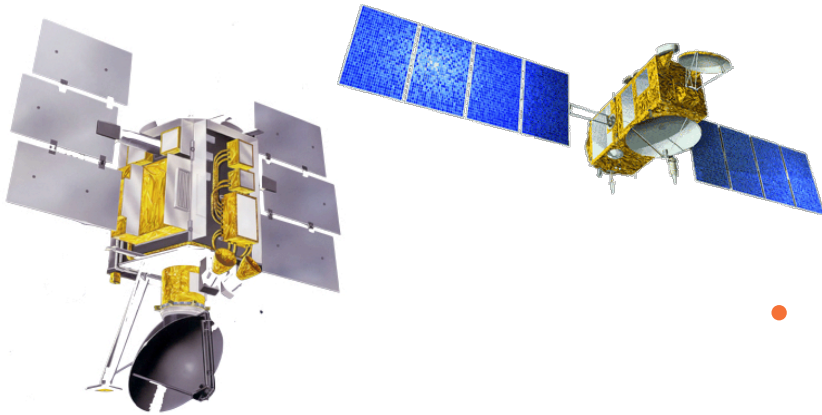
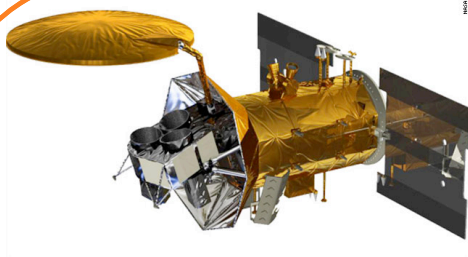
- **Complementary technologies:**

- Satellites give global coverage, fine spatial detail in (x,y)
- Moorings sample across timescales, allow co-located ocean-atmosphere observations, velocity sampling
- Argo resolves fine vertical structure, adds salinity, maps subsurface T and S and connects to subtropics

- **New scientific understanding and issues:**

- Role of high-frequencies, especially the diurnal cycle
- Focus on the coupled boundary layers
- Physical-biogeochemical connections and impacts

Assimilating models integrate diverse observations  
Users will increasingly rely on gridded products



We view the tropical Pacific as consisting of a broad interior plus four “boundary layers”:

Surface, Equatorial, Eastern and Western

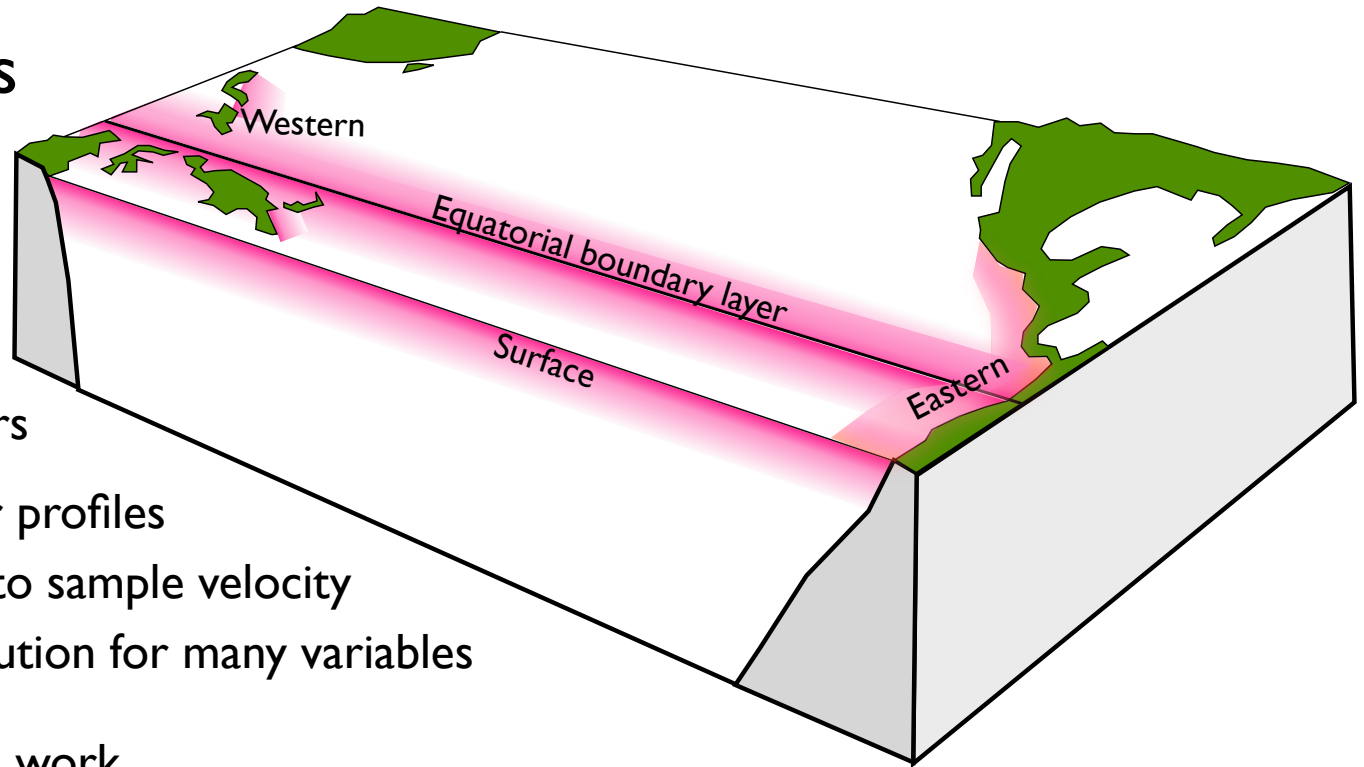
The boundary layers are the hard parts

We quickly understood that away from the boundary layers

- Argo is a better solution for profiles
- Moorings are the only way to sample velocity
- Satellites have made a revolution for many variables

That was the first 90% of the work.

The boundary layers are the “other 90%”, and that work is unfinished (pilots recommended).





# The First Report

- Published 30 December 2016 (ref. GCOS-200)
- 22 Recommendations
- 15 Actions
- First published design following the GOOS Framework

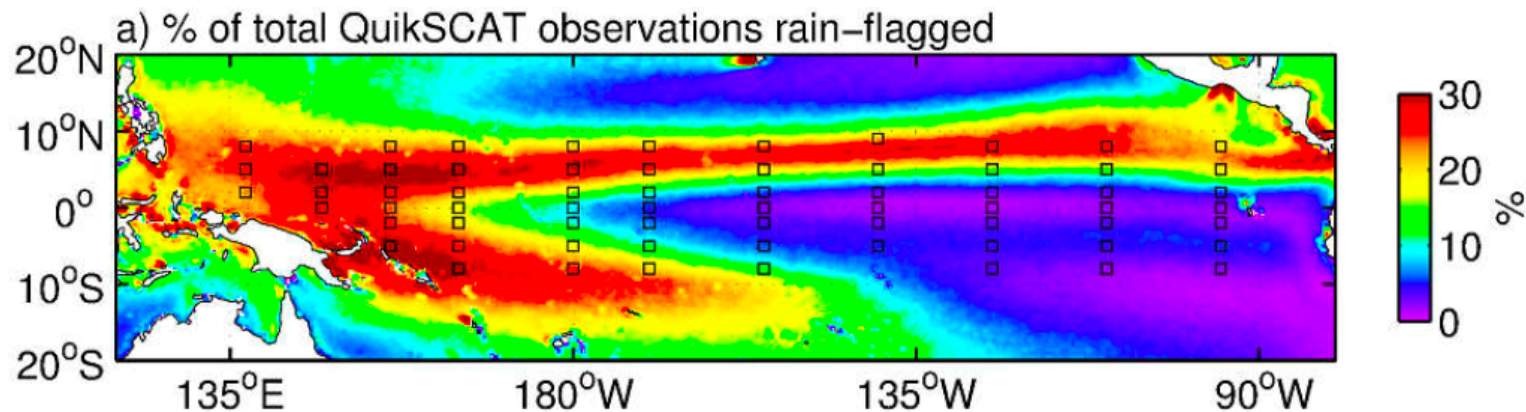
[tpos2020.org/first-report](https://tpos2020.org/first-report)

(much of this applies to the other tropical oceans!)



# Specific Recommendations (1)

- Seek integration of satellite observations. Winds!!!
  - Need both in situ and satellite wind observations. Drove much of our work.



QuikSCAT rain-flag frequency during 1999-2009.

Over much of the Pacific ~25% of QuikSCAT samples are flagged as potentially invalid due to rain.

This does not mean that scatterometer winds are unusable under rain, but they are in question. It is also true that wind products from different centers differ significantly.

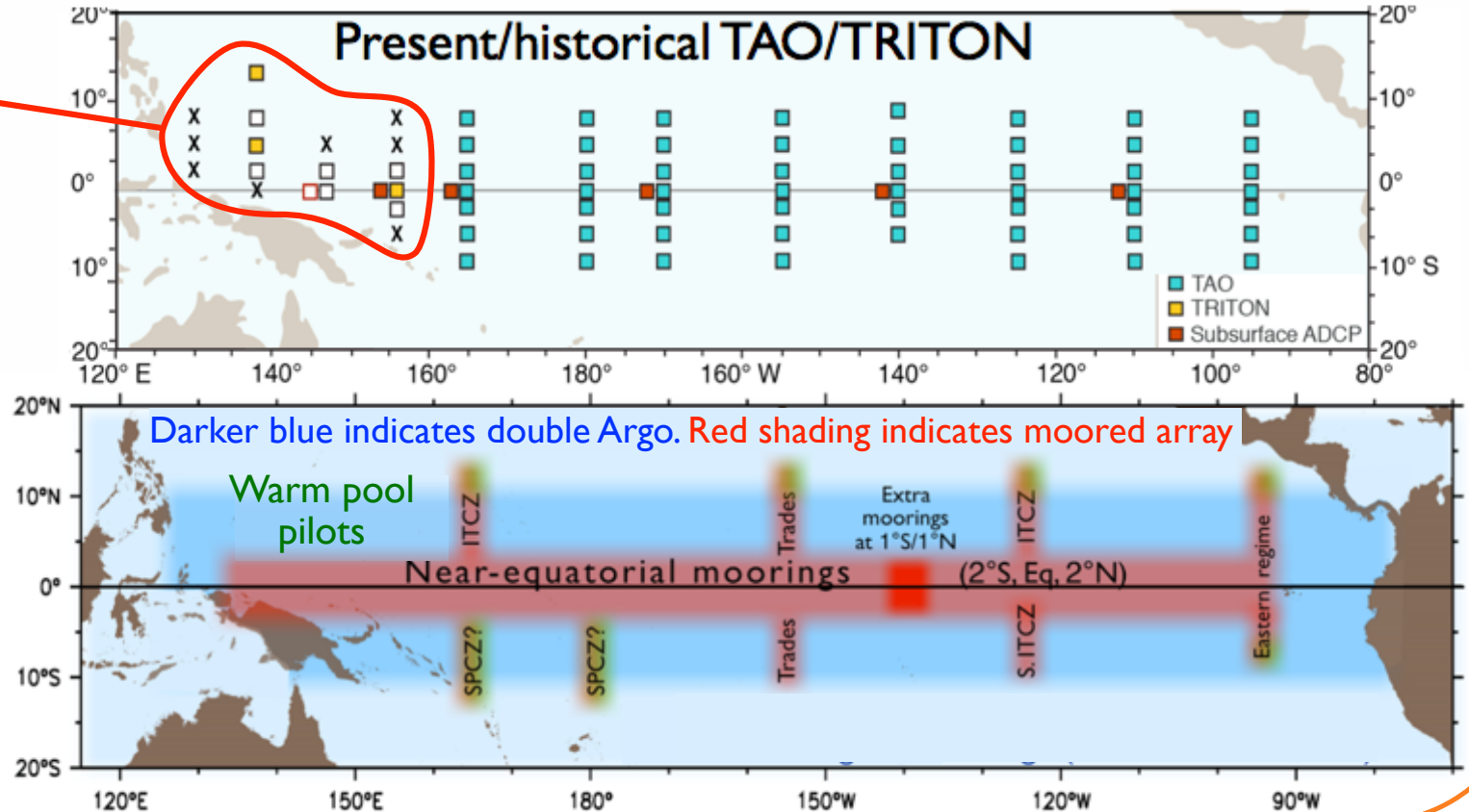
The global climate is exquisitely sensitive to the equatorial zonal wind, so we must get this right.



# Specific Recommendations (2)

- Double Argo within  $10^{\circ}\text{S}$ - $10^{\circ}\text{N}$
- Reconfigure the moored array:
  - more capable moorings, targeting: the equatorial circulation, the mixed layer and its interaction with the atmosphere, and key regimes

Former  
TRITON



The eventual  
in situ  
“backbone”





# Specific Recommendations (3)

- **Model/data assimilation development is essential**
  - To integrate the information from diverse platforms
  - Models themselves need guidance from process experiments
  - Data assimilation development needs .... time?
- **Initiate pilot and process studies (next page)**
  - To guide the future design using the most effective combination of platforms and technologies

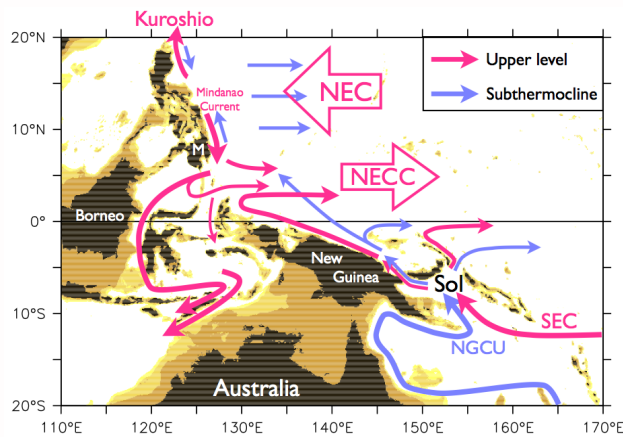
Again, many proposed TPOS pilot/process studies apply broadly.

→ Some could be done in any tropical ocean.

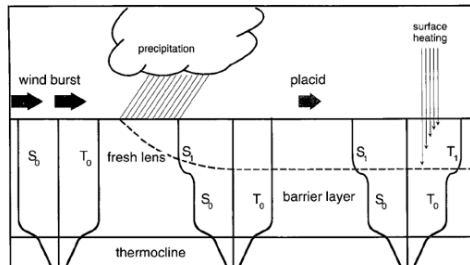


# Advance: Research required!

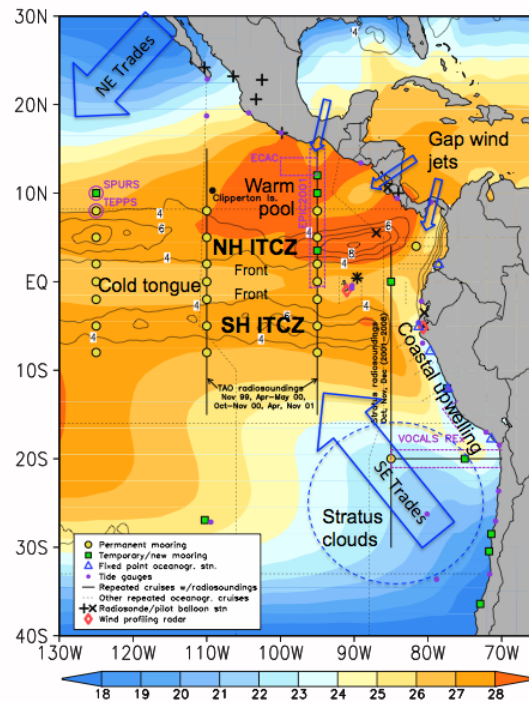
- **Pilot studies** enhance TPOS capability
- **Process studies** to understand phenomena
- **Modeling studies** add value to observations, show their impact



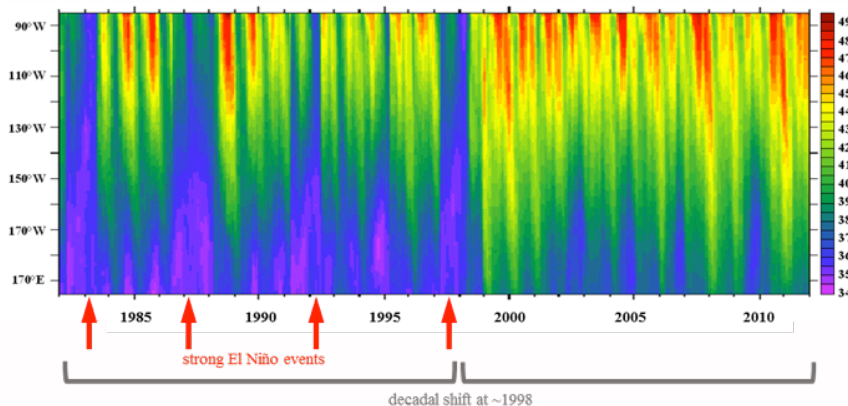
Low-latitude western boundary currents and the Indonesian Throughflow are principal conduits of tropical-subtropical interaction.



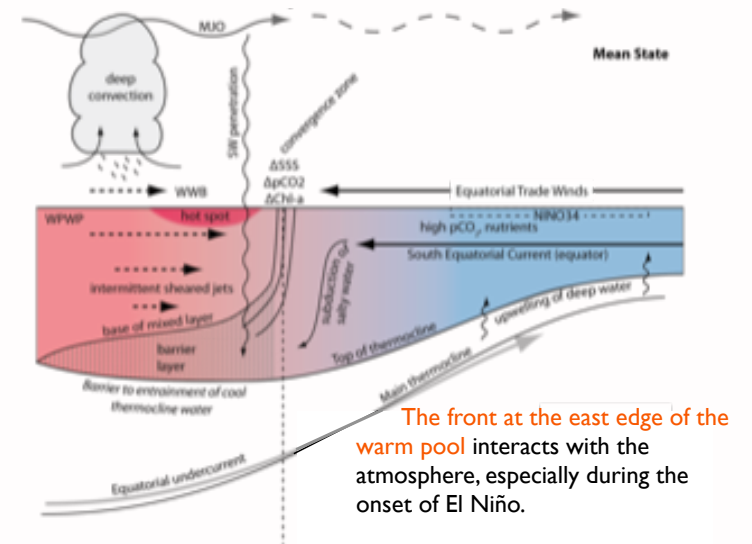
Barrier layers in the west Pacific warm pool affect the penetration of momentum fluxes.



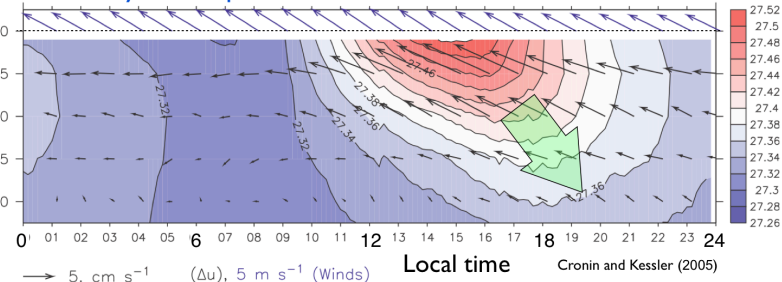
Critical processes in the east include the stratus/cold tongue front/ITCZ system and coastal upwelling.



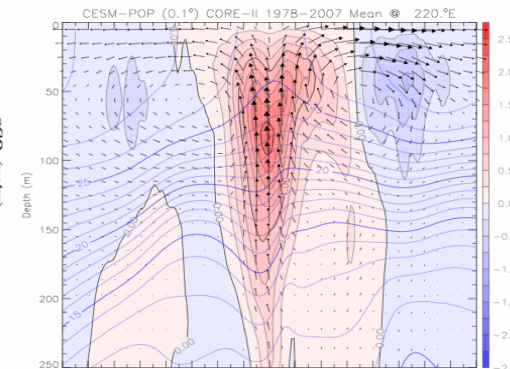
The 30-year record of surface  $p\text{CO}_2$  shows strong annual, interannual and decadal variability of  $\text{CO}_2$  fluxes in the east Pacific cold tongue.



Diurnal cycle composite at  $2^\circ\text{N}, 140^\circ\text{W}$ : Winds, current shear.



The diurnal cycle can be an important mechanism allowing downward propagation of heat and momentum fluxes.



Equatorial upwelling is fundamental but poorly known; its modeling is uncertain.

# Four newly-funded OOMD pilots for TPOS 2020

- Autonomous surface vessels for PBL and surface BGC observations
  - Argo enhancements for rainfall, windspeed and biogeochemistry
  - Enhanced ocean boundary layer observations from TAO moorings
  - Direct covariance flux measurements from TAO moorings
- (About \$4.5M over 3 years)

The Saildrone might change how we sample the surface met and ocean.

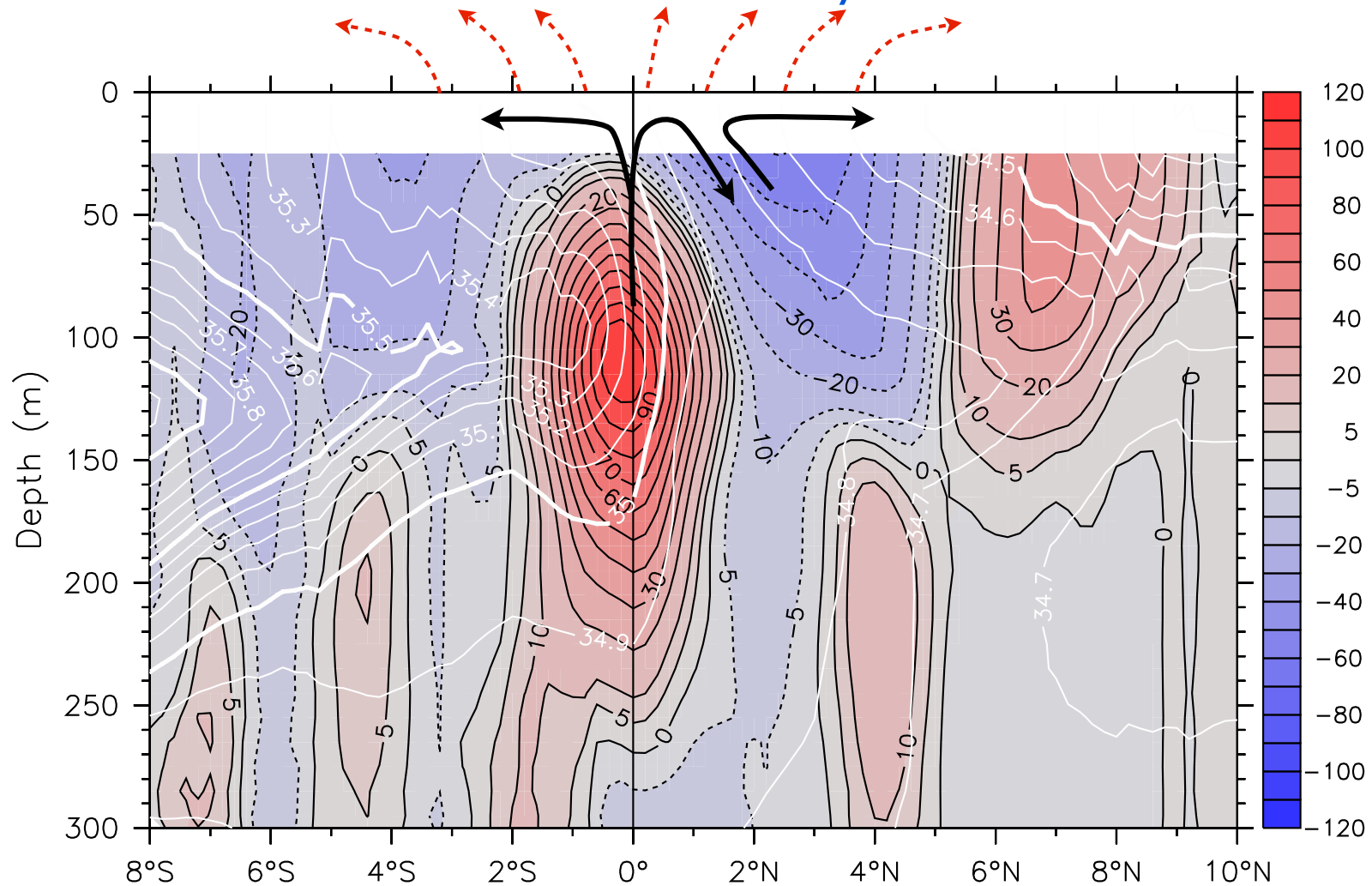
It has great promise, but needs real-world testing to build confidence and learn its full capabilities and limitations.

Saildrone in the Bering Sea, July 2016



# Equatorial upwelling produces coupled feedbacks

Coupled interactions radiate globally,  
and feed back locally



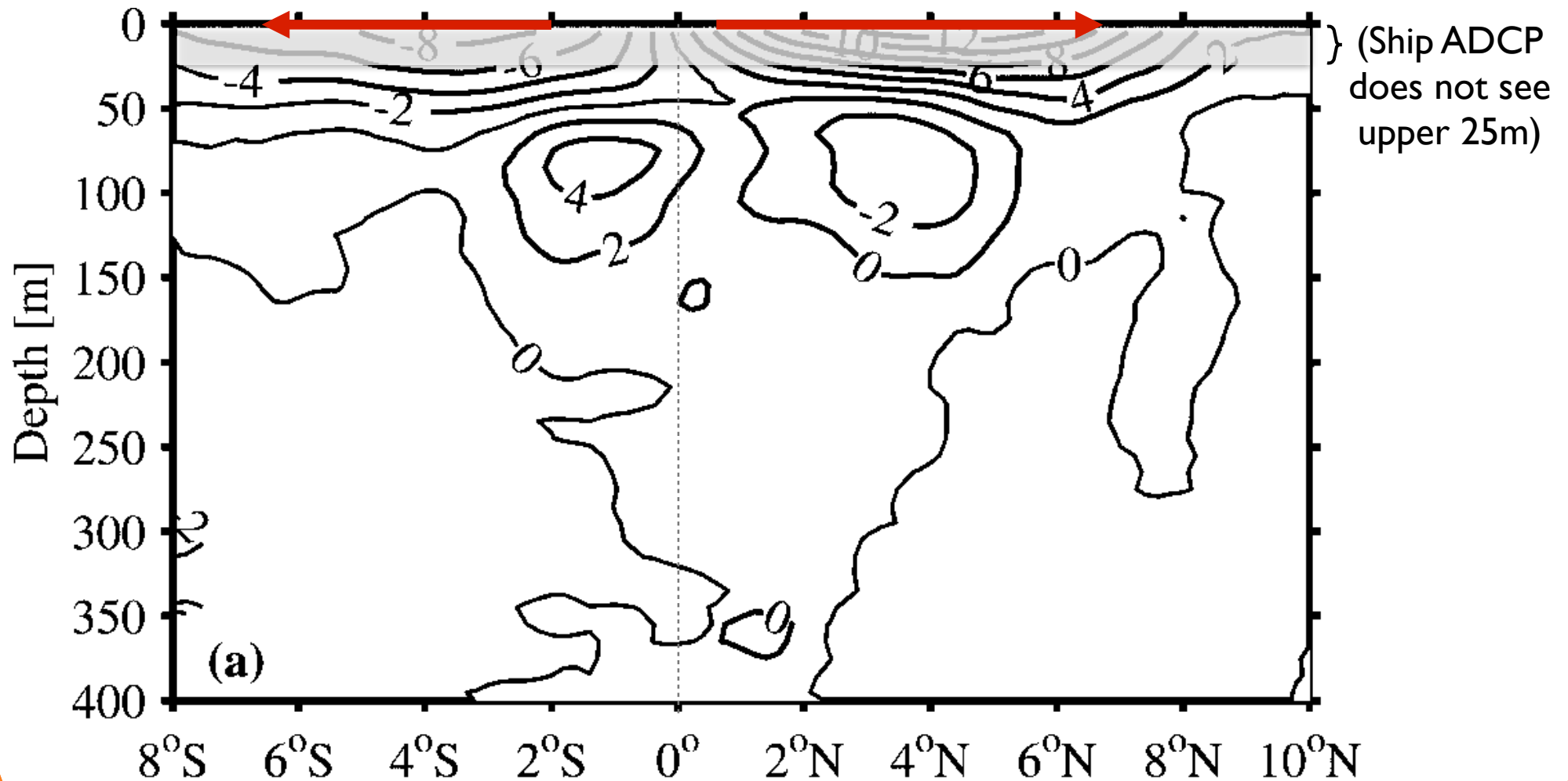
Mean zonal current (colors) and salinity (white contours) at 140°W (sketch of w)



Johnson et al. (2001)

# Observed $v$ in the east-central Pacific

Average of shipboard ADCP from 170°W-95°W



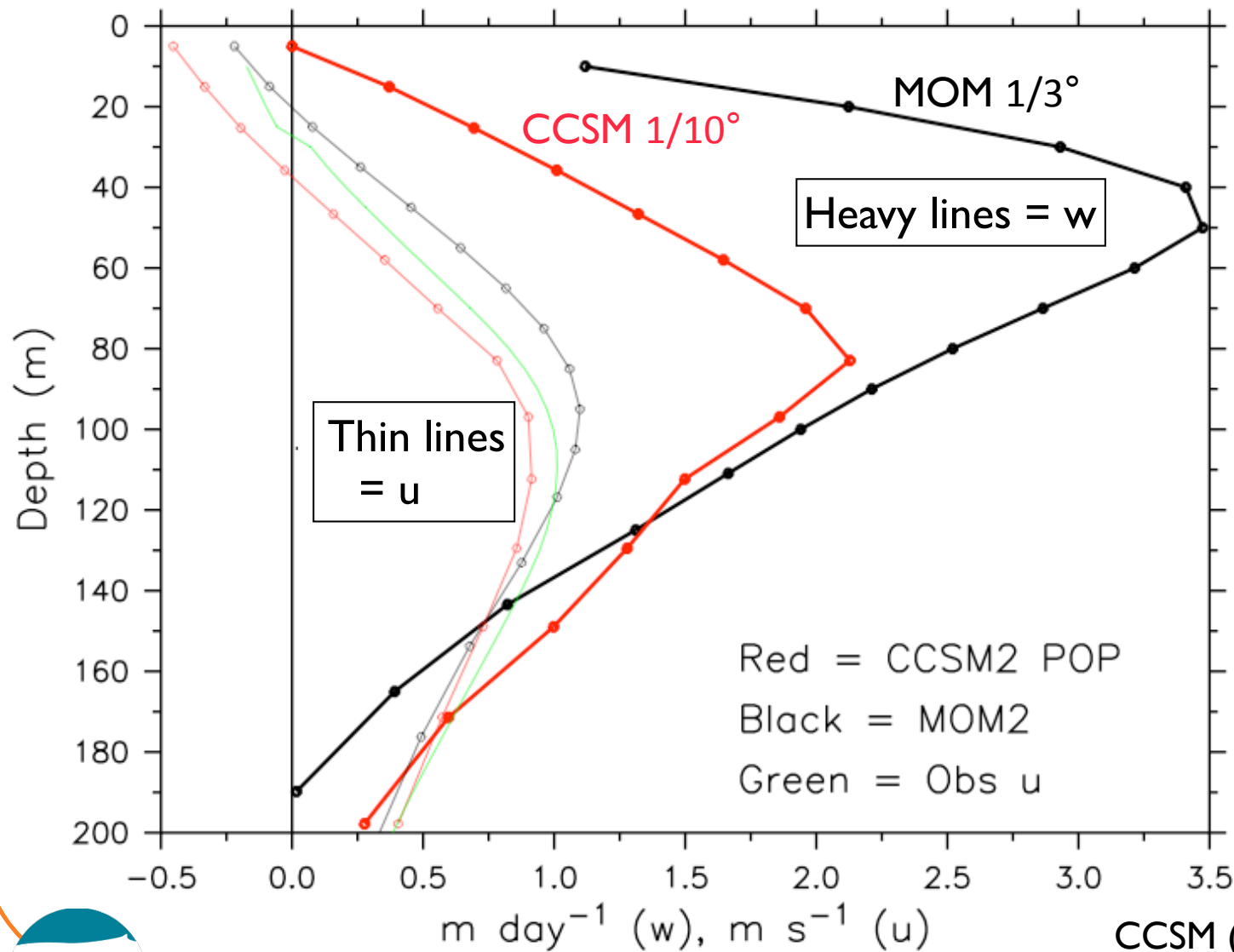
Johnson et al. (2001)





# How do models represent this circulation? (We don't know!)

Mean  $u$  and  $w$   
at  $0^\circ, 140^\circ\text{W}$



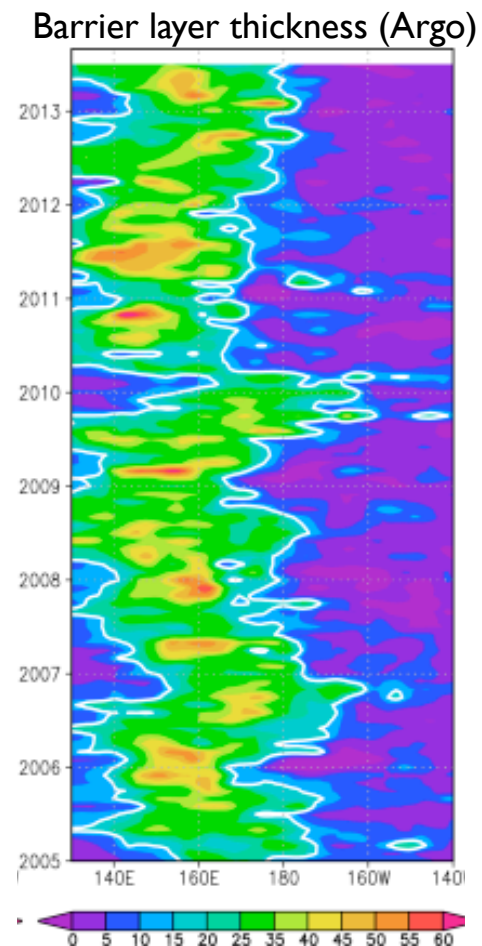
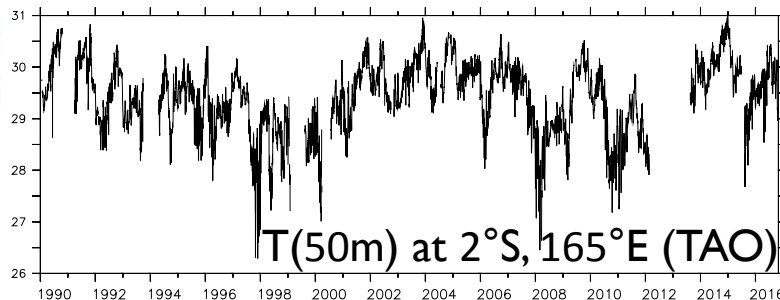
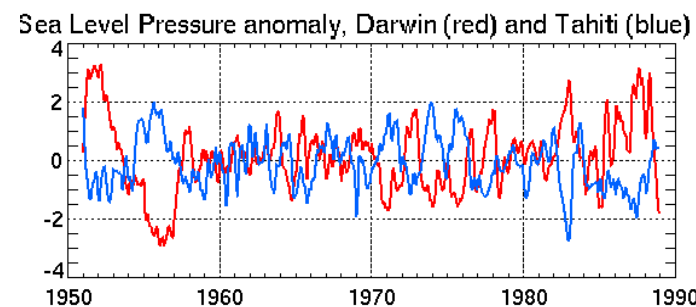
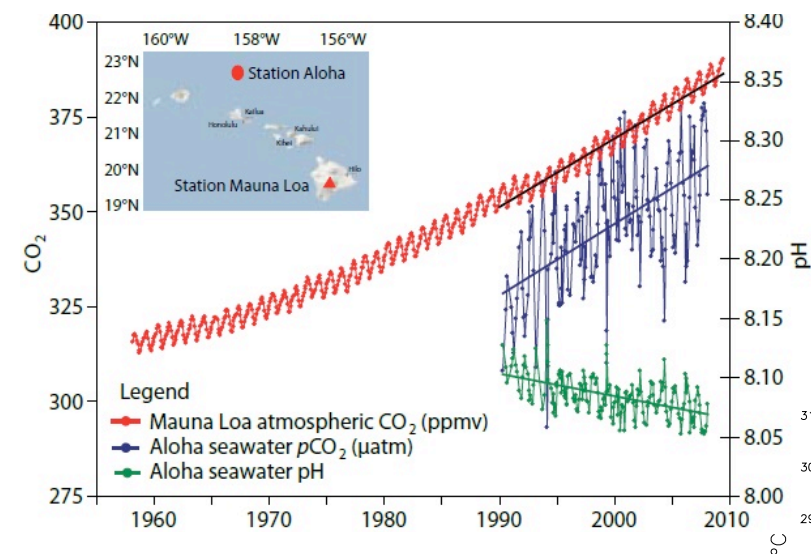
The usual model-data  
comparisons of  
 $u(\text{Eq}, z)$  can be  
misleading



# Why do we propose changes, when the tropical Pacific is not over-sampled now?

A “climate data record” is a time series at a point (examples).

A “climate record” is a set of measurements that enable detection and accurate description of an element of climate variability in its longterm context.

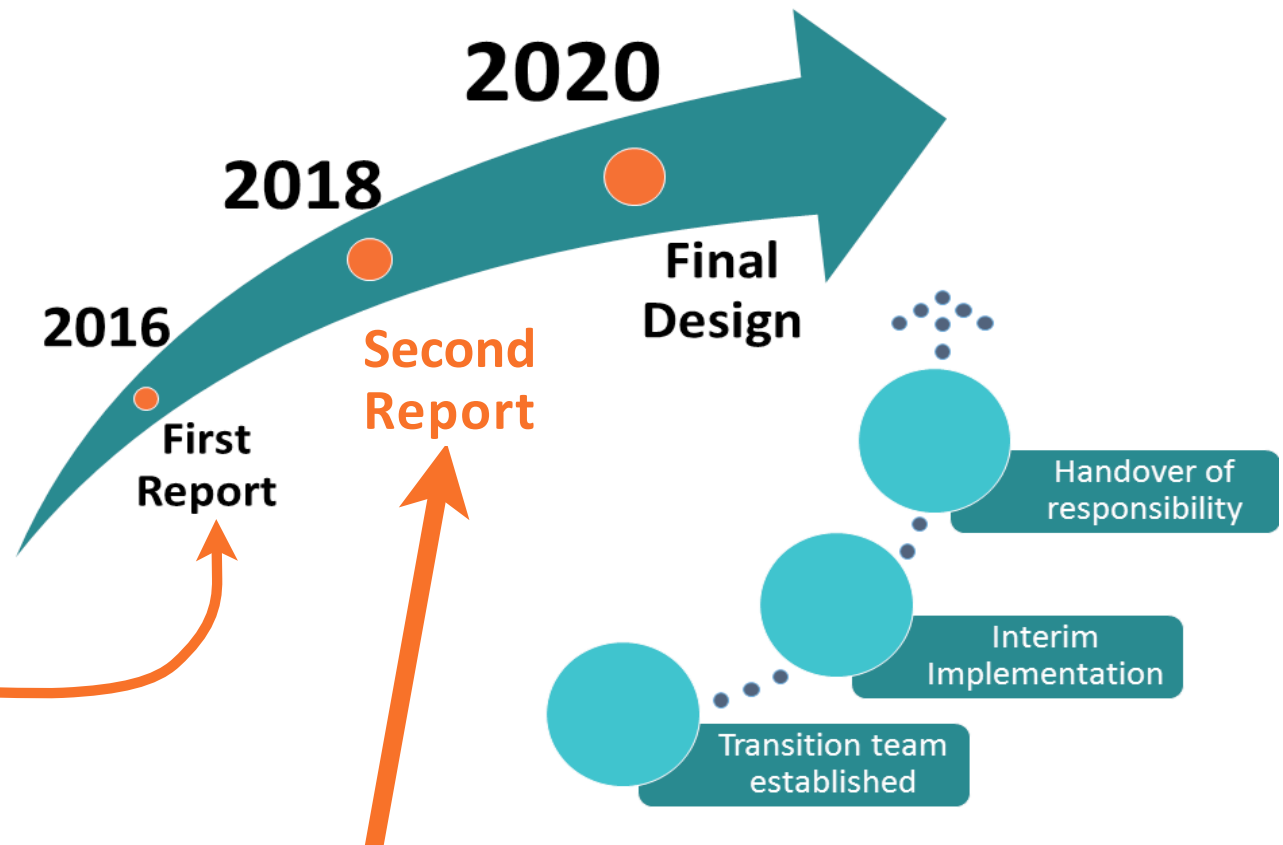


# Risks

- In real life, funding might not respect the climate record.
- In our focus on  $T(z)$  and winds, we have neglected other important consequences:  
Nothing replaces the buoy surface met: Humidity and  $T_{\text{air}}$ , thus the LHF.  
Will those measurements turn out to be a key validator:
  - For coupling processes in models of 2030?
  - Or of techniques to infer these from future satellite retrievals?
  - How much flux measurement is needed? Where?
- Reducing mooring service cruises will damage the 25-year  $p\text{CO}_2$  record. Autonomous vehicles may mitigate this, but ...



# Next steps



## Second report focii:

- Improving modelling and data assimilation
- Biogeochemical and ecosystem observations (Beyond pCO<sub>2</sub>, what?)



# Momentum, opportunity

- Several agencies are moving forward strongly
  - NOAA, SOA, JAMSTEC, ... will discuss plans 16-17 May (Resources Forum)
  - Engaging WMO Members through JCOMM, WIGOS, WMO
- Needs and opportunities:
  - Seek engagement for Pilot/Process studies,
    - e.g., in the boundary regions: Best methods to monitor the WBCs and ITF?
    - Refine sustained sampling design:
      - Learn to monitor key processes from sparse sustained data
  - Promote development of assimilation systems to integrate diverse data sources

